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Radiation Safety

Guide

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THE NATIONAL INSTITUTES OF HEALTH RADIATION SAFETY GUIDE

INCLUDING:

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Introduction

The National Institutes of Health is authorized to procure and use radioactive materials on the Bethesda reservation under a "specific license of broad scope" issued by the Division of Materials Licensing of the Nuclear Regulatory Commission. This license is contingent upon the existence of a Radiation Committee and a Radiation Safety organization which, among other requirements must:

1. Assure that any investigator using radioactive materials is qualified by training and experience, has the facilities to handle the materials safely, and proposes a use which is safe to all concerned.

2. Assure observance of all safety standards established by the Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, and other regulatory or standards setting agencies.

3. Keep records of the receipt, storage, use, transfer, and ultimate disposal of all radionuclides used at NIH.

4. Keep records of the monitoring of personnel and areas involved in the use of radionuclides and other sources of ionizing radiation.

NIH is subject to periodic inspections by the Division of Regulatory Operations of the Nuclear Regulatory Commission to insure that all requirements of the license are being met. These inspections are very thorough, including monitoring checks of laboratory areas, inspection of procurement and disposition records, records of the qualifications of individual users, and records of administrations to patients. Violations of license requirements can result in a loss of the license.

All sources of ionizing radiation are not covered by the Nuclear Regulatory Commission license. These sources are, however, controlled by regulations issued by the Director, NIH, upon recommendation of the Radiation Committee. Non-license sources include x-ray machines, high voltage accelerators, electron microscopes, and radioactive materials from sources other than reactor by-products.

This Guide describes rules and procedures required of NIH under the terms of NRC licensure, and for the use of non-licensed ionizing radiation sources as set forth by NIH regulations.

In total, the 1979 revision of the NIH Radiation Safety Guide represents several decades of intramural experience. Additionally, it reflects authoritative standards, guidelines, recommendations and research data concerning physical aspects and bioeffects of ionizing radiation obtained from the scientific literature.

Previous editions of this Guide included a reasonably comprehensive bibliography of the most important of these sources; the literature is now so extensive, however, that it is not feasible to include even a highly selective bibliography. Therefore, readers who desire documentation for any particular policy, procedure or quantitative data contained in these pages are invited to communicate directly with the NIH Radiation Safety Office.

National Institutes of Health Radiation Protection Guide

Ionizing radiation is among the most versatile and useful tools of modern medicine and biomedical research. Like many other instrumentalities of medicine and research, ionizing radiation is potentially hazardous unless used with strict adherence to safety rules and procedures.

The risk of unguarded exposure to ionizing radiation includes the possibility of damage to future generations. Thus the safety rules which govern all uses of ionizing radiation are as concerned with preventing genetic damage as with protecting the health of the exposed individual. When followed faithfully, these rules limit exposures of radiation workers to levels far below those which might cause any adverse somatic or genetic effects.

The rules and procedures set forth in this Guide have one single, straightforward purpose—to protect NIH patients and employees against unnecessary and potentially harmful radiation exposure.

Four stages of group and individual responsibility are involved in the radiation safety program. All are equally important:

Radiation Committee: this is a high-level group of physicians and scientists appointed by the NIH Director to establish policies and regulations governing the use of ionizing radiation in NIH intramural programs.

Radiation Safety Office: an operating group of trained health physicists and technicians which is responsible for NIH-wide compliance with these policies and regulations; it also provides a variety of technical services necessary to achieving such compliance.

Individual Users: physicians, scientists, other professionals, as well as technical and other workers engaged in patient care, clinical and laboratory research, and research support activities which involve actual use and handling of materials and devices producing ionizing radiation. These personnel usually work under the immediate supervision of Authorized Users.

Authorized Users: physicians and laboratory scientists whose training and experience are such that they have been authorized by the Radiation Committee to use ionizing radiation in their clinical care, clinical research, and laboratory research activities.

In the following pages detailed descriptions are given of the responsibilities of each of these four categories. Information is also provided on policies, rules and procedures for various particular aspects of ionizing radiation source procurement and usage. Careful observance of responsibilities, rules and procedures set forth in this Guide will insure adequate protection against unnecessary exposure to ionizing radiation.

Radiation Committee Responsibility

The Radiation Committee is composed of ten members appointed by the Director, NIH. The membership consists of one group of five physicians who are nominated by the Medical Board and, in conformity with NRC recommendations, is made up of one hematologist, one radiologist, one pathologist, one internist, and one physician with broad background in the use of radionuclides. A second group of four scientists is nominated by the Scientific Directors. At least one of these scientists is to be a radiation physicist with training and experience in health protection. The Chairman of the Radiation Committee, the Radiation Safety Officer, and a representative of the Office of the Director are appointed by the Director, NIH. The Committee shall have jurisdiction over radiation sources and activities in areas under NIH control, including intramural program off-site use.

Functions

(a) Recommend policies regarding patient and plant radiation safety to the Director, NIH.

(b) Provide technical advice to the Radiation Safety Officer on matters regarding radiation safety.

(c) Receive, review, and act on all applications for the use of radiation sources in any areas used by NIH personnel. These sources include radionuclides to be used in human subjects.

(d) Receive and review periodic reports from the Radiation Safety Officer on monitoring, contamination, and personnel exposure.

(e) Periodically review the overall use of radiation sources at NIH from the standpoint of operational hazards.

(f) Review all instances of alleged infraction of use and safety rules with the Radiation Safety Officer and the responsible Clinical and Scientific Directors before submitting reports or recommendations to the Director, NIH.

Radiation Safety Office Responsibility

The Radiation Safety Office, under the direction of the NIH Radiation Safety Officer, is responsible for:

1. General surveillance of all health physics activities, including both personnel and environmental monitoring.

2. Furnishing consulting services to personnel at all levels of responsibility on all aspects of radiation protection.

3. Receiving, delivering, and shipping all radioactive materials coming to or leaving the NIH reservation.

4. Assaying and performing radionuclidic purity checks on all radioactive materials to be used in humans for therapeutic purposes.

5. Monitoring all accelerators and other machines capable of producing penetrating radiations. Calibrating the output of these machines as requested.

6. Distribution and processing of personnel monitoring equipment including the keeping of records of internal and external personnel exposure, and notifying individuals and their supervisors of exposures approaching the maximum permissible amounts and recommending appropriate remedial action.

7. Instructing personnel in proper procedures for the use of radioactive materials.

8. Supervision and coordination of the waste disposal program, including the keeping of waste storage and disposal records.

9. Operation of and the allocation of space in the Radionuclide Laboratory, Building 21. This laboratory is equipped for the handling of high levels of activity. Space is available in this laboratory to all NIH workers on an allocation basis. Non-tracer level radionuclide work will be done in this building unless the Radiation Committee grants approval to do the work elsewhere.

10. Storage of all radioactive materials not in current use.

11. Performing leak test on all sealed sources.

12. Maintaining a periodic inventory of all radioactive materials on the NIH reservation.

13. Supervising decontamination in cases of contaminating accidents.

14. Maintaining a continuous program of environmental radiation hazard evaluation and hazard elimination.

Individual User Responsibility

Each individual at NIH who has any contact with radioactive materials is responsible for:

1. Keeping his exposure to radiation as low as possible, and specifically below the maximum permissible exposure as listed in the following table:

REMS PER CALENDAR QUARTER	
Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1.25
Hands and forearms; feet and ankles	18.75
Skin of whole body	7.5

Also see additional guidelines for maximum permissible doses, e.g., for fertile females and the fetus

Laboratory air and water concentrations shall be maintained below the levels listed in the Code of Federal Regulations, Title 10, Part 20 (10 CFR 20) "Standards for Protection Against Radiation," (See Appendix)

2. Wearing the prescribed monitoring equipment such as film badges and pocket dosimeters in radiation areas. Personnel who work only with pure alpha emitters or only with pure beta emitters having a maximum energy of less than 0.2 MeV will not be required to wear film badges.

3. Surveying his hands, shoes, and body for radioactivity, and removing all loose contamination before leaving the laboratory to smoke, eat, etc.

4. Utilizing all appropriate protective measures such as:

(a) Wearing protective clothing whenever contamination is possible, and not wearing such clothing outside of the laboratory area.

(b) Wearing gloves and respiratory protection when necessary.

(c) Using protective barriers and other shields whenever possible.

(d) Using mechanical devices whenever their aid will assist in reducing exposure.

(e) Using pipette filling devices. *Never pipette radioactive solutions by mouth.*

(f) Performing radioactive work within confines of an approved hood or glove box unless serious consideration has indicated the safety of working in the open.

5. Avoiding smoking or eating in radionuclide laboratories. It is recommended that eating be done in the cafeterias whenever possible. Smoking or eating may be permitted in an office area of a laboratory that has been demonstrated to be free of contamination. Refrigerators shall not be used jointly for foods and radioactive materials.

6. Maintaining good personal hygiene.

(a) Keep fingernails short and clean.

(b) Do not work with radioactive materials if there is a break in skin below the wrist.

(c) Wash hands and arms thoroughly before handling any object which goes to the mouth, nose, or eyes.

7. Checking the immediate areas, e.g., hoods, benches, etc., in which radioactive materials are being used, at least once daily for contamination. A log record should be maintained of these surveys including results which are entirely negative. Any contamination observed should be clearly marked and the Radiation Safety Office notified.

8. Keeping the laboratory neat and clean. The work area should be free from equipment and materials not required for the immediate procedure. Keep or transport materials in such a manner as to prevent breakage or spillage (double container), and to insure adequate shielding. Wherever practical, keep work surfaces covered with absorbent material, preferably in a stainless steel tray or pan, to limit and collect spillage in case of accident.

9. Labeling and isolating radioactive waste and equipment, such as glassware, used in laboratories for radioactive materials. Once used for radioactive substances, equipment should not be used for other work, and *shall not be sent from the area to central cleaning facilities, repair shops, or to surplus, until demonstrated to be free of contamination.*

10. Requesting Radiation Safety office supervision of any emergency repair of contaminated equipment in the laboratory by shop personnel or by commercial service contractors. At no time shall servicing personnel be permitted to work on equipment in radiation areas without the presence of a member of the laboratory staff to provide specific information.

11. Reporting accidental inhalation, ingestion, or injury involving radioactive materials to his supervisor and the Radiation Safety Office, and carrying out their recommended corrective measures. The individual shall cooperate in any and all attempts to evaluate his exposure.

12. Carrying out decontamination procedures when necessary, and for taking the necessary steps to prevent the spread of contamination to other areas.

13. Complying with requests from the Radiation Safety Office for body burden measurements in the whole body counter and the submission of urine samples for radioassay. Requests for these tests will be made in the case of workers using significant quantities of both γ and β emitters.

Authorized User Responsibility

Authorized users are responsible for insuring that the preceding individual responsibilities are discharged by those under their control, and are further responsible for:

1. Adequate planning. Before an experiment is performed, the supervisor should determine the types and amount of radiation or radioactive material to be used. This will generally give a good indication of the protection required. The procedure must be well outlined. In many cases, before the procedure is actually performed with radiation, it should be rehearsed so as to preclude slip-ups or unexpected circumstances. In any situation where there is appreciable radiation hazard, the Radiation Safety Office shall be consulted before proceeding.

2. Instructing those employees for whom they are responsible in the use of safe techniques and in the application of approved radiation safety practices and insuring attendance in required radiation safety courses.

3. Furnishing the Radiation Safety office with information concerning individuals and activities in their areas—particularly, pertinent changes in their personnel rosters.

4. Contacting the Radiation Safety Office whenever major changes in operational procedures, new techniques, alterations in physical plant (e.g., the removal of radiochemical fume hood), or when new operations which might lead to personnel exposure are anticipated.

5. Complying with the regulations governing the use of radioactive materials, as established by the NRC and the NIH Radiation Committee, for:

(a) Correct procedure for the procurement of radioactive materials by purchase or transfer. (See procedure for Procurement of Radiation Sources.)

(b) Posting areas where radionuclides are kept or used, or where radiation fields may exist.

(c) Seeing that each sign carries the name of the personnel currently responsible for the associated area.

(d) Recording the receipt, transfer, and disposal of radioactive materials in his area. This includes sealed sources such as ion sources in gas chromatographs and static eliminators. The authorized user must be prepared to submit semiannually the required inventory data upon request.

(e) Assuring that all radioactive waste materials are consigned to the Radiation Safety Office for disposal.

(f) Taking steps to prevent the transfer of radioactive materials to unauthorized individuals. This includes the proper disposition of radioactive materials possessed by terminating workers.

6. Keeping stocks of stored radioactive materials to a minimum within laboratory areas. Authorized users should employ the storage facilities of the Radionuclide Laboratory, Building 21, for shipments not needed in current research.

7. Complying with proper procedure for termination of employment or termination of any experiment using radioactive materials. The authorized user is reminded that, under the terms and conditions of the NRC-NIH license, he must return to the Radiation Safety Office all radioactive materials, including waste, assigned to him under the license. Particular care should also be exercised to see that specialized equipment such as personnel monitoring devices (e.g., film badges), survey instruments, and shielding materials are returned to the Radiation Safety Office. A final termination survey should also be requested by telephone.

Policies and Procedures for Radionuclide Areas

In addition to the Code of Federal Regulations, Title 10, Parts 19 and 20, as appended to the Guide, the following policies and procedures will apply to the NIH license:

1. Proper Marking of Laboratories, Areas, and Equipment

(a) A "CAUTION RADIOACTIVE MATERIALS" sign must be conspicuously posted on the doors to laboratory areas where radioactive materials are being used or stored. The name and home phone number of the individual responsible for the posted area shall be shown in the designated place on the sign in order to facilitate contact in case of emergency. The supervisor shall be responsible for seeing that the posted information is current. The signs must not be removed from any room except by Radiation Safety personnel following an inspection survey.

(b) Storage areas shall be conspicuously marked with a "CAUTION RADIOACTIVE MATERIALS" sign. In addition, containers in which materials are transported or stored shall bear a durable, clearly visible label bearing the radiation caution symbol and the words "CAUTION RADIOACTIVE MATERIALS." This label shall also state the quantities and kinds of radioactive materials in the containers and the date of measurement of the quantity.

(c) Radiation areas in the laboratory, i.e., areas where radiation levels might expose individuals to 5 millirem in any one hour; or in any five consecutive days, a dose in excess of 100 mrem, shall be posted with the sign "CAUTION RADIATION AREA."

(d) All equipment contaminated with radioactive material shall be marked with signs, decals, or other conspicuous means. Labeling shall not be required for laboratory containers such as beakers, flasks, and test tubes, used transiently in laboratory procedures during the presence of the user.

(e) All signs referred to in this part are available from the Radiation Safety Office, Building 21.

2. Shielding of Sources

(a) Radioactive sources or stock solutions in the laboratory shall be shielded in such a manner that the radiation levels in any occupied area will not expose individuals in the area to more than 100 mrem in any five consecutive days.

(b) Various shielding materials are available on loan from the Radiation Safety Office.

3. Aerosols, Dusts, and Gaseous Products

(a) Procedures involving aerosols, dust or gaseous products, or procedures which might produce airborne contamination shall be conducted in a hood, dry box, or other suitable closed system.

(b) All releases from such systems shall not exceed the maximum permissible concentration in air for the nuclide in question. See Appendix B, Table II of 10 CFR 20 for appropriate values. However, where practical, traps should be incorporated in the experimental set-up to insure that environmental releases are as low as possible.

(c) Radioactive gases or materials with radioactive gaseous daughters must be stored in gas-tight containers and must be kept in areas having approved ventilation.

(d) Hoods to be used for radionuclide work should be tested by the Environmental Services Branch, DRS, to insure that they meet the minimum requirements for air velocity at the face of the hood.

4. Sealed Radioactive Sources

(a) All sealed radioactive sources must be shipped to: Radiation Safety Officer, National Institutes of Health, Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014. Each source must be registered with this office.

(b) For those sources which may change location frequently, the Radiation Safety Office in cooperation with individual users shall establish strict accountability procedures.

(c) Sealed sources shall be leak tested by Radiation Safety personnel prior to initial use and at least every six months thereafter.

5. Radioactive Materials in Gas Chromatography Equipment

All gas chromatography units in which radioactive materials are to be used are regulated as follows:

(a) As is true with other radioactive shipments, radioactive foils to be used in gas chromatography cells must be shipped to: Radiation Safety Officer, National Institutes of Health, Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014. Each foil must be registered by number with this office.

(b) In addition, each cell containing a radioactive foil must have a label showing:

The radiation caution symbol with the words "CAUTION RADIOACTIVE MATERIAL"; and

The identity and activity of the radioactive material.

The radioactive foil shall not be removed from its identifying cell except for cleaning and shall not be transferred to other cells.

(c) The following notice shall appear in a conspicuous location on the outside of each gas chromatography unit: "This equipment contains a radioactive source registered with the NIH Radiation Safety Office as required by license from the Nuclear Regulatory Commission. Notify the Radiation Safety Office before removing the source from this room or area, or upon any change in custodial responsibility." These notification tags are available from the Radiation Safety Office, Building 21.

(d) Individuals using radioactive components in gas chromatography equipment must vent the cell-exhaust through plastic tubing into a hood, room exhaust, or Radiation Safety approved trap, to avoid contamination of work areas from the release of radioactive tagged samples introduced into the system or from the accidental overheating of radioactive foils in the cells.

(e) The Radiation Safety Office will perform periodic leak tests, store radioactive foils when not in use, and maintain the necessary records on such tests and storage.

6. Work Surfaces

All work areas (bench tops, hood floors, etc.) as well as storage areas and areas adjacent to permanent set-ups and sinks should be covered at all times with stainless steel or plastic trays, uncracked glass plates, or other impervious materials. For some purposes a plastic-backed absorbent paper (e.g., "Kimpak", available from the Central Storeroom) will be satisfactory. However, if such paper is used, it should be discarded frequently to prevent radioactive materials from dusting off the surface.

7. Periodic Surveys of Radiation Areas

The immediate areas (e.g., hoods, bench tops) in which radioactive materials are being used should be checked for contamination at least once daily by the radiation workers in that laboratory. In addition, these areas should be inspected each and every time there is reason to suspect a contamination incident. *Records shall be kept on both positive and negative survey results in the authorized user's laboratory logs.*

8. Laboratory Monitors

Each laboratory or area (other than those where ^{3}H is used exclusively or where only exempt quantities of other radionuclides are handled) shall be equipped with a portable or semiportable monitoring device to be used for personnel and area monitoring. Laboratory monitors of this type are available on loan from the Radiation Safety Office.

9. Removal of Equipment from the Laboratory

Once used for radioactive substances, equipment shall not be used for other work, or sent from the area to central cleaning facilities, repair shops, surplus, or returned to the source of supply, until demonstrated to be free of contamination. Equipment to be removed from the Radionuclide Laboratory, Building 21, must be cleared through the Radiation Safety Office.

10. Repair and Maintenance of Equipment in the Laboratory

Equipment to be repaired by shop and maintenance personnel, or by commercial service contractors, shall be demonstrated to be free of contamination prior to servicing. If it becomes necessary to make emergency repairs on contaminated equipment, the work will be supervised by a member of the Radiation Safety Office staff, who will assure that the necessary safeguards are taken. It is the responsibility of the laboratory personnel to request this supervision from the Radiation Safety Office.

11. House Vacuum Lines

House vacuum lines are vulnerable to contamination. If house vacuum lines are to be used, the withdrawn gas must be demonstrated to the Radiation Safety Office to be free of radioactivity. It is advisable to use a separate vacuum system whenever possible, such as a separate vacuum pump exhausting into a hood.

12. Radioactive Contamination of Areas

In general, no radioactive contamination can be tolerated. Exceptions to this will include certain hood trays, dry boxes, stainless steel trays, Kimpak covered surfaces; or other equipment which is used frequently for active work and which will be clearly marked with the standard radiation caution signs or stickers. Any contamination that is not confined to protected surfaces should be reported immediately to the Radiation Safety Office. The Radiation Safety staff will supervise the decontamination of such areas or equipment.

13. Decontamination of Areas Contaminated with Radioactivity

Preparations for decontamination should be begun promptly. Determine the extent and hazard of contamination. The Radiation Safety Office staff will assist in this evaluation. The individual responsible for the contamination will be expected to do most of the cleanup under the supervision of the Radiation Safety staff. After decontamination, the area or equipment shall be considered contaminated until proved otherwise by the Radiation Safety Office.

14. Decontamination of Personnel Contaminated with Radioactivity

(a) Notify supervisor immediately after contaminating accident.

(b) Wash body area involved thoroughly for 2 or 3 minutes, repeatedly "soaping" and rinsing. Consideration should be given to the chemistry of the contaminant and an attempt made to find a suitable agent for dissolving it. Any cleansing agent may be used, but synthetic detergents are preferred to soaps. Avoid prolonged use of any one decontamination procedure. Irritation of the skin may impede the success of more suitable procedures. Avoid the use of organic solvents. They may make the skin more permeable to radioactive contaminants.

(c) If this procedure is not immediately and completely effective, notify the Radiation Safety Office and proceed at once to the Medical Officer in charge of the Building 10 Health Unit, Occupational Medicine Service. Special decontaminating agents such as "Versene", "Radiacwash", etc. may be used under the direction of the Medical Officer.

15. Prophylactic Thyroid Blocking Agents in Laboratories Using Radioiodine

Individuals utilizing greater than 10mCi radioiodine should consult with and follow the recommendations of the Occupational Medical Service prior to the use of prophylactic thyroid blocking agents. Such individuals are reminded that the use of these blocking agents in no way reduces the need to take all other precautions in the safe handling of radioiodine.

Radioactive Waste

No radioactive wastes shall be disposed of by conventional methods. This means particularly that solid wastes may not be placed in the standard waste containers to be collected by housekeeping personnel, and that liquid wastes may not be discharged into the sewer. Animals must not be incinerated in the general purpose incinerator.

No radioactive waste shall be released from a laboratory area for pickup and disposal prior to autoclaving or otherwise suitable deactivation of infectious agent(s). Radioactive waste disposal procedures in the waste handling area of the Radionuclide Laboratory, Building 21, involve crushing and compacting of dry wastes by compaction devices and pooling of liquids in approved shipping containers for disposal by a licensed contractor. These procedures are not compatible with the proper handling of infectious agents. Similar considerations shall also be given to other highly toxic or hazardous substances. (See Section 3)

Physician's Responsibility and Procedures

In carrying out the responsibilities and duties assigned it by the NRC under the Broad License and by the Director, NIH, the Radiation Committee requires compliance with the following policies and procedures:

1. Experience and Training of Applicants

The Committee is bound by the requirements of NRC for training and experience of physicians in the use of radioactive materials. These requirements are listed in "Nuclear Regulatory Commission Licensing Guide—Medical Programs." Copies of this report are available for reference from both the Radiation Committee office and the Radiation Safety Office.

2. Procedures for Making Application to the Committee

A separate application is required for each project which contemplates the use of radioactive materials in humans. This application must include:

(a) Form NIH-88-23: A self-explanatory form available from the Chairman, Radiation Committee.

(b) Narrative description of project which shall include:

(1) Title of the project.

(2) A statement of the purpose and justification for the use of radionuclides.

(3) Description of the project; including methods, characteristics of radioactive materials (half-life, nature and energy of emissions, modes of decay), details of doses (single and total) and the anticipated results. Reference to previous work published by the applicant or others concerning animal experimentation or human use (including doses) should be carefully documented. The Committee requires a clear, concise calculation of the anticipated whole body and critical organ absorbed dose in rads, stating the period of such exposure and radiation hazards, if any. Include uptake and excretion data. The formula used for such calculation should be clear, all terms defined, and the source and estimated reliability of the formula indicated. Assumptions used for estimates should be stated. Assay methods and estimated efficiencies should be given.

(4) Methods of waste disposal, particularly with respect to urine, stools, exhaled air, and calculation of the daily amounts of radioactivity to be disposed of into the sewer or air, if any.

(5) Safety precautions which will be initiated to protect the patient, other patients in the vicinity of the radioactive patient, and the patient-care staff and adjunct personnel.

(6) If the use of the radioactive material is planned for normal human subjects, the application must specify minimum ages of these subjects, the fact that they are volunteers, cognizant of the possible radiation hazards, and the status of such normal subjects with respect to other contacts with radiation, and cumulative exposure. In addition, the Radiation Committee requires a short statement from the investigator regarding the information he would supply to the volunteer pursuant to obtaining his consent.

(c) With the first application from each investigator, a complete description of his training and experience, stating periods, location and supervision in the use of radionuclides (Form NIH-88-2, NIH-88-24).

Upon completion, this application should be forwarded through the Branch Chief, and the Clinical Director of the applicant's Institution to the Chairman of the Radiation Committee. Action of the Committee will be returned through channels to the applicant and copies will be forwarded to the Radiation Safety Officer and to the Chief, Radiopharmaceutical Section. The signed approved original will constitute the investigator's authorization under the Broad NRC License to procure and use the materials. Physicians may obtain information on current approved investigators and specific medical uses at NIH from the Radiation Committee office.

Should questions arise in the Committee regarding details of an application, the investigator will be invited to meet with the Committee and discuss the details of his proposal. Should the Committee finally disapprove the application on the basis of conflict with restrictions of the NRC or Director, NIH, or Committee policies, the application nevertheless will be forwarded to NRC for its review and action upon further recommendation of the investigator and his Clinical Director.

Each authorization will be marked with an expiration date which will usually be the last day of the month, one year after the month of the approval. Authorized investigators should anticipate the expiration of their approvals by at least one month and apply for renewal of the authorization. For this purpose, it is necessary to submit only the Form NIH–176 (without narrative description) and a "Summary of Use of Radioactive Materials," Form NIH-88-25. The investigator should clearly state that this is an application for renewal of the previous authorization without modification, and should include the number of the original authorization and date.

If an investigator has no positive plans for the use of a given authorization during the coming year, he should consider its retirement in order to save on bookkeeping in the Radiation Committee, Radiation Safety and Radiopharmacy offices. Such a retired authorization can usually be reactivated by the Chairman, Radiation Committee, in one day should need for it develop.

An authorization which is being considered for renewal and which reflects frequent patient use may be retained and established as a service to be provided to the clinician and patient by the Department of Nuclear Medicine. Decision to provide this service will reside with the Chief, Department of Nuclear Medicine. This service consideration would also be applied in the situation where several similar authorizations by separate applicants reflect an overall need for patient service from various areas of the Clinical Center.

After receiving the approved Form NIH-88-23, the investigator should comply with the procedures "Procurement of Radiation Sources" listed elsewhere in this Guide.

3. Responsibility

The authorized investigator has primary responsibility for the use of the radioactive material; for the protection of the patient, and for the safe handling of any material removed for study. The Radiation Safety staff is responsible for the protection of the patient-care staff, for instructions needed to insure radiation-safe conditions, and for the handling of contaminated materials, equipment, and waste. *Any delegation of work does not shift responsibility.*

Special instructions regarding patient treatment shall be on Clinical Record SF–508. Radiological safety precautions will be recorded on Form NIH–88-7.

4. Justification

The widely accepted policy for medical uses of radionuclides is that radioactive substances should never be used in humans except when the investigation or treatment justifies the risk involved. It is NIH policy to encourage use of the most sensitive instrumentation and assay procedures available, and

to promote progressively better techniques aimed at reducing radiation doses. All research and diagnostic procedures should be designed with these policies in mind.

The therapeutic uses of radiation in other than malignant disease should be well justified. Applications for therapeutic uses of radiation will be reviewed by the Radiation Committee in accordance with instructions from the Director, NIH, and the Medical Board.

5. Dosage Considerations

As a general guide to the maximum permissible dose for normal volunteers and for patients, the Radiation Committee follows the recommendations of the National Council on Radiation Protection and Measurements Report No. 39, "Basic Radiation Protection Criteria" and Code of Federal Regulations, Title 21, (Food and Drugs) Part 361. Insofar as is practical, the Committee considers that the dose to normal subjects and patients should be limited to 3.0 rems to any tissue within a 13 week period or 5 rems annually, when diagnostic and experimental purposes permit. When it is necessary to exceed this dosage for the purposes of research or diagnosis because instrumentation of the required sensitivity is not available, the applicant will be required to provide justification for doses higher than these values. For all normal volunteers under the age of 18 years, and patients under the age of 18 years, and all pregnant women, this limit is reduced to 10% of the above values.

Larger doses will be considered by the Committee for use in patients with limited life expectancy (two years or less) when the application adequately justifies the procedure and the importance of the contribution which is anticipated by the use of such doses.

When considering the utilization of radioactive materials for human research and diagnosis, the investigator is urged to carefully consider the following factors:

(a) Body retention of the radioactive materials.

(b) Accumulation in critical tissues.

(c) Size of critical organ.

(d) Radiosensitivity of the tissue.

(e) Biological half-life.

(f) Effective half-life.

(g) Type and energy of the radiations.

(h) Accumulation of effects of combined or sequentially administered radioactive materials.

(i) Concomitant use of x-radiation.

6. Calibration and Nuclidic Purity Tests

Prior to administration, all radionuclides are to be calibrated and tested for nuclidic purity by the Radiopharmaceutical Section. Indicated pyrogen and sterility testing is to be arranged by the Radiopharmaceutical Section.

7. Notification of Nursing Staff

In order that the nursing staff may prepare for therapeutic radionuclide administration, the head nurse of the nursing unit which will care for the patients should be notified as far in advance as possible, preferably 24 hours or more. Those connected with the administration of the radionuclide should become familiar with nursing procedures to insure uniformity of precautions.

8. Area Designation

It is not necessary to isolate patients with routine diagnostic doses nor to post their rooms. Patients with therapeutic doses should be confined to their individual rooms, as distant from the nursing station as feasible, and the room posted with a "Radiotherapy Precautions" sign (available from the Radiation Safety staff). The Radiation Safety staff will conduct daily surveys of the patient area following therapeutic doses, removing contaminated materials such as urine, soiled bedding, etc., when necessary, and instituting controls so that the patient-care staff, adjunct personnel, and visitors are not exposed to radiation levels in excess of applicable guides. The physician in charge is responsible for requesting assistance from the Radiation Safety staff in the event of contaminating accidents, and prior to removal of the patient from therapy precautions.

9. Record of Patient Doses

The authorization number and any dose of a radionuclide administered to a patient together with the other required data shall be recorded immediately on the patient's chart using Form PHS–412, "Radioactive Isotope Exposure Record."

10. Radioactive Waste and Disposal

Radioactive contamination of room air and sewerage should not exceed the limits approved by the NRC as stated in 10 CFR 20 (found elsewhere in this Guide). When wastes exceed these limits, they shall be disposed of with the assistance of the Radiation Safety staff.

11. Radioactive Contaminated Equipment

The authorized physician is responsible for arranging for the safe disposal of all radioactive solutions and contaminated equipment such as syringes, etc. This may be accomplished by removal to the individual's laboratory for proper decontamination or storage for decay, or by contacting the Radiation Safety staff for disposal. Under no circumstances should such solutions or equipment be left on the nursing unit, or the responsibility for disposal of these materials be delegated to the nursing staff. The Radiation Safety Officer strongly recommends the use of

disposable syringes and needles for the administration of radionuclides. Disposable syringes containing only the usual residual fluid may be disposed of in the regular dry radioactive waste containers available on the nursing units. Disposable needles may also be put into the regular dry radioactive waste containers ONLY after they have been capped or after the needle point has been inserted in a small cork. This is necessary in order to preserve the integrity of the plastic bag lining the container and to protect personnel handling these liners.

12. Laboratory Specimens

There exists a danger that highly radioactive tissue specimens, blood, ascitic fluid, excreta, or cadavers may be delivered to the laboratory or pathology services, without being adequately labeled. To minimize this possibility, all specimens from such patients which are to be sent to a laboratory must be labeled "Radioactive." Preferably, the laboratory should be called in advance to give them additional information, such as the amount of activity and special handling techniques required, if any. This includes tissue specimens, ascitic fluid, blood, urine, feces, emesis, etc.

Exemptions:

(a) When the time elapsed between the administration of the radionuclide and the time of obtaining the specimen is such as to render the specimen (in the opinion of the physician in charge of the patient or in the opinion of the Radiation Safety Officer) no longer a hazard from either a health or a contamination standpoint.

(b) When the radionuclide is administered in such a way that it remains localized and does not enter significantly into the general circulation (such as colloidal gold injected into the prostate), and the specimen is excreta or a tissue removed at a site sufficiently distant from the injection site so that it is unlikely to contain any of the radioactive material.

13. Cadavers

If a patient who has received a therapeutic dose of any radionuclide dies in the hospital within a three (3) week period after that dose, the authorized physician is requested to do the following:

(a) Tie a radioactive hazard sign to the body writing on it the specific radionuclide amount given, and the date of administration.

(b) Place the Form PHS–412 as the top sheet in the chart and write across the face of this sheet "Radioactive Body."

(c) Notify the Radiation Safety Officer. During off-duty hours the Guard Office in Building 31 should be requested to notify one of the persons on the call list maintained for such emergencies. The Radiation Safety Officer must be notified as he is responsible for giving the pathologist suitable safety instructions and for giving the required information to the funeral director.

Procedures for Nursing and Patient Care Staff

1. Diagnostic Procedures

Since there is minimal external hazard to others from routine diagnostic doses of radionuclides, there are no restrictions on the patient's activities or his contacts with other people. Nursing personnel are not required to wear personnel monitoring devices.

The following procedures apply when a patient receives radioactive material for diagnostic purposes:

(a) The Chief Nurse of the unit should request a Geiger counter and dry radioactive waste can from the Radiation Safety staff to be kept in the utility room.

(b) Patient-care personnel should use disposable gloves to handle items suspected of contamination. Particular care should be exercised in the handling of vomitus and excreta during the first 24 hours following administration of the radionuclide. Use the Geiger counter to check for contamination. Contaminated linen should be placed in a yellow laundry bag which is kept in the patient's room. Other contaminated items should be placed in the radioactive waste container. Call the Radiation Safety Office for removal of such contaminated linen and waste.

(c) Laboratory samples taken during the first days post administration should be labeled "Radioactive," as per physicians orders.

(d) Special diagnostic procedures will be evaluated on an individual basis and appropriate written instructions may be issued.

(e) Should questions arise concerning the use of radionuclides on a unit, call the Radiation Safety staff for assistance.

2. Therapy Procedures

The following procedures apply when patients receive radionuclides other than sealed sources or colloi-

dal suspensions, in millicurie amounts for therapeutic purposes:

(a) Special Radiation Safety Procedures (Form NIH-88-7) will be issued to the Chief Nurse of the unit at the time the radionuclide is given or at the time the patient is returned from the operating room. This form will indicate precautions to be taken on a daily basis and will be reviewed each day by Radiation Safety personnel.

(b) A "Radiotherapy Precautions" sign shall be placed at the patient's door. Radiation Safety personnel will indicate when it may be removed.

(c) The patient should be put in a room by himself. For patients receiving gamma-emitting nuclides, this room should be as distant from the nursing station as feasible. *Exception*: Patients receiving radiation source implants (radium or iridium needles) or colloidal suspensions may be placed in a room with another patient providing this second patient is receiving external beam therapy.

(d) Handling of Patient

1. When indicated on the Form NIH-88-7, the patient-care staff should wear disposable gloves while handling the patient. Used gloves should be placed in the radioactive waste can for disposal.

2. Wash hands thoroughly with soap and running water after gloves are removed.

3. After handling the patient, patient-care personnel should monitor themselves thoroughly using the Geiger counter provided for this purpose.

(e) Food Service

If feasible, paper plates and disposable utensils should be used by the patient during therapy precautions. If found contaminated after use, they should be placed in the waste container provided for this purpose.

(f) Patient's Linen

All linen, i.e., bedclothes, pajamas, towels, etc., used during the period of therapy precautions must be placed in a yellow laundry bag to be kept in the patient's room, and must not be sent to the laundry until monitored by Radiation Safety personnel.

(g) Removal of Objects and Materials From Patient's Room

All objects or materials to be removed from the therapy precautions area shall be checked for contamination. It may be necessary to remove these articles temporarily to the utility room for monitoring, due to the radiation levels in the vicinity of the patient.

(h) Disposal of Radioactive Excreta

1. Feces should be passed in the toilet whenever possible. If a bedpan is used, it must be handled with disposable gloves. The same bedpan should be used until treatment is completed and its use restricted to that particular patient.

2. Urine shall be saved in stoppered bottles and if the radionuclide is a gamma-emitter, the bottles shall be kept in a shielded storage container provided by the Radiation Safety staff. Urine container, urinals, specimen bottles, etc., should be handled only by the patient if at all possible.

(i) Housekeeping Personnel

Housekeeping personnel shall not enter the room unless indicated on the Form NIH-88-7.

(j) Accidents

In case of an accident which might produce a radiation hazard (e.g., the spillage of contaminated urine on the floor),

CALL AT ONCE:
During Regular Working Hours
The Physician in Charge,
Radiation Safety Officer,
and
Chief of Nursing Service.
Outside of Regular Working Hours:
Nursing Supervisor in Charge,
Physician in Charge,
and
Guard Office in Building 31 for names of Radiation Safety Office personnel on call.

3. Colloidal Suspensions and Sealed Sources

The following apply when patients receive therapy utilizing colloidal suspensions or sealed sources, such as needles, tubes and plaques containing iridium-192, cobalt-60, radium, radon, etc.:

(a) All dressings, bedclothes, sanitary napkins, bedpans, etc., or any material removed from the vicinity of the treatment site shall be carefully monitored to assure that the source has not been removed or displaced.

(b) The above-mentioned items (a), (b), (c), and (i) of Part 2 shall also apply.

(c) Items (d), (e), (f), (g), and (h) do not apply to these cases since there is little if any chance of contamination.

(d) The nursing staff should be alert to any sealed sources which may have moved from their original positions. Should an implanted source become separated from the patient, proceed as in 2-(j) above.

Radiation Producing Equipment Operator's Responsibility

The operator of any radiation producing equipment is responsible for:

1. Notifying the Radiation Safety Office when there is any change in the setup, i.e., new equipment installed, changes in shielding, change in output of radiation, or change in usage of the unit.

2. Requesting and wearing appropriate monitoring devices. Always wear the assigned monitoring device (e.g., film badge) when working with the unit. Whenever protective lead aprons are worn, the body monitor should be worn on the outside of the apron at the neckline. In addition, wrist monitors are to be worn if the unprotected hands and forearms must come in close proximity to the beam.

3. Keeping exposure as low as possible. The operator must never expose himself to the direct beam, and must not stand within one meter of the tube or irradiated target while the unit is in operation unless adequately shielded. Make full use of protective barriers, lead aprons, gloves, and goggles.

4. Clearing the area of all nonessential personnel. The operator should insist that all nonessential personnel leave the exposure area before operating the unit, and that all essential personnel be adequately shielded.

5. Observing any restrictions on the use of the unit recommended by the Radiation Safety staff.

6. Adequate dark adaptation. The eyes of the fluoroscopist should be well dark-adapted before he uses a fluoroscope without image intensifying equipment. It is inexcusable to increase the output of the unit to compensate for poor dark adaptation.

7. Using minimum exposure factors. Fluoroscopic work shall be performed in the minimum time possible using the lowest dose rate and smallest aperture consistent with clinical requirements.

8. Visually monitoring tube current and potential of fluoroscopic equipment with image intensifiers at frequent intervals, because under automatic brightness control these variables can rise to high values.

9. Recording data of fluoroscopic and cineradiographic studies on patients on Form NIH–378, "Radiation Exposure Record," and maintaining this form in the patient's record.

10. Notifying the supervisor and the Radiation Safety Officer immediately of any accidental exposures to radiation.

11. Keeping the unit disconnected or locked when not in actual use.

Policies for Radiation Producing Machines and Areas

1. All operating personnel and personnel in the immediate area will be required to wear a film badge or other personnel monitoring device.

2. Areas in which radiation producing machines are located or are being used shall be posted with the characteristic "CAUTION RADIATION" sign. In addition, the controls shall bear a decal with the statement: "CAUTION RADIATION—This equipment produces radiation when energized." Labels and decals are available from the Radiation Safety Office.

> *Exception:* Diagnostic and patient treatment areas need not be so marked, provided that a person is charged with the responsibility for protection of employees, patients, and authorized visitors against radiation injuries, and for the execution of Radiation Safety recommendations.

3. The structural shielding requirements of any new installation, or an existing one in which changes are contemplated, shall be discussed with the Radiation Safety staff.

4. An annual, scheduled survey of all radiation producing equipment used on patients shall be made by Radiation Safety personnel. In addition, radiation surveys will be made of all new installations and all existing installations after every change that might increase the radiation hazard (e.g., replacement of x-ray tube, changes in filtration of beam).

5. Unless measurements indicate that they are not needed, protective aprons shall be worn by the physician, nurse, technician, and all other persons within the room or area who are frequently or habitually exposed to radiation.

6. Dose rates for the beam shall be determined for all units used on human subjects and will be reported to the operator in milliroentgens per milliampere-second or milliroentgens per minute. The "Radiation Exposure Record," Form NIH–378, shall be completed for fluoroscopic and cineradiographic studies and maintained in the patient's record.

7. In the operation of mobile and dental units:

(a) The operator should stand as far as possible from the tube and patient during exposure, and should wear a protective apron, or step behind an adequate shield.

(b) An operator, standing at least 6 feet from the tube and patient, should not make more than 5,000 milliampere-seconds of exposure during any one week. Rotation of operators or the use of portable shields is recommended for greater workloads.

8. The hand of the fluoroscopist should never be placed in the useful beam unless the beam is attenuated by the patient and a protective glove of at least 0.25 mm lead equivalent is worn.

9. No person shall be regularly employed to hold patients during exposure, nor shall anyone from the Diagnostic Radiology Department ever be permitted to perform such service. The person holding the patient shall wear protective gloves and a protective apron. No part of this person's body should be in the unattenuated useful beam.

10. If safe use of the installation depends upon mechanical restriction of the orientation of the radiation beam, or upon limitations (voltage, current, time, permanent filter, and maximum aperture) in the output of the unit, then these restrictions shall be rigidly followed.

11. Shutter mechanisms and interlocking devices should not be tampered with and shall be inspected at frequent intervals to insure proper operation.

12. All protective devices that may become defective due to use or abuse, such as protective lead aprons or gloves, should be inspected for radiation leakage at least every six months, or whenever the integrity of the equipment is suspect.

13. A manually reset cumulative timing device shall be used which will either indicate elapsed time or turn off the apparatus when the total exposure reaches a certain previously determined limit.

14. In cineradiography, tube currents and potentials are often higher than those used in fluoroscopy. Thus, special care should be taken to limit patient exposure. The exposure rates on these cineradiography units shall be determined during the annual survey.

15. X-ray diffraction equipment can be particularly hazardous because of high exposure rates in the primary beam (e.g., in excess of 500,000 roentgens per minute at the x-ray tube port).

(a) A radiation survey shall be made by the Radiation Safety staff before a new installation is placed in routine operation and whenever changes are made which could adversely affect radiation protection. The equipment shall be frequently inspected for radiation leakage and a radiation survey shall be made at least annually by Radiation Safety personnel.

(b) Appropriate operating procedures and safety measures approved by the Radiation Committee shall be established and followed for these units.

16. Personnel specifically responsible for such equipment shall insure that all workers in the area are monitored in accordance with the requirements for the specific unit.

17. For larger, individually licensed irradiators and accelerators, specific operating and emergency procedures shall be established and posted. All users of this equipment shall operate it in compliance with these posted instructions.

18. All interlocks, visual and audible warning devices, and monitoring equipment shall be inspected for proper operation at six month intervals by Radiation Safety personnel.

Procurement of Radiation Sources

The following procedures for the procurement of radiation sources are intended to insure compliance with the terms and conditions of the license issued by NRC, and the regulations imposed by the Director, NIH:

1. The Radiation Safety Officer must be notified in advance of the procurement of all radiation sources whether ionizing radiation producing machines, NRC-licensable or accelerator-produced radionuclide, radium, or other radioactive materials.

2. When the use of radiation sources is planned, the investigator must indicate to the Radiation Committee his training and experience in this area. This is done by submitting one copy of the Form NIH-88-2 "Application for Use of Radioisotopes at the National Institutes of Health" to the Radiation Safety Office. When the investigator makes application to the Committee, it is understood that *he accepts the responsibility for complying with the regulations governing the safe use of sources in NIH controlled areas.*

3. Upon notification of approval of his qualifications, the investigator then submits Form NIH–88–1, "Request for Purchase and Use of Radionuclides," to the Radiation Safety Office. The form covers only the quantities specified on a single requisition. The form must be completed regardless of the method of acquisition. In cases other than purchase, the form serves as the required notice to the Radiation Safety Office that the receipt of radioactive materials is contemplated through gifts or transfers from any source.

4. Established users of the NIH license may procure radionuclides under the Telephone Charge Order (TCO) system, provided all conditions of the Small Purchase Procedures Manual (NIH Manual Handbook 2600–103–26.9) are met. Authorized investigators are reminded that: the dollar limit for radionuclides is $500 and for radionuclides being used under the NIH Broad License delivery must be made within ten (10) days to: *Radiation Safety Officer, National Institutes of Health, Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014.* See Small Purchase Procedures Manual for step-by-step instructions for obtaining radionuclides by TCO and for list of TCO Account Suppliers.

5. Purchase orders exceeding $500 will be requisitioned in the usual manner by using Form PHS–402–1, "Requisition for Equipment and Supplies," which shall be clearly labeled *"Radionuclide Order."* The requisition must be completed in all normal respects and, in addition, specify that delivery be made to the *Radiation Safety Officer, National Institutes of Health. Building 21, Radionuclide Laboratory, Bethesda, Maryland 20014.* The requisition and accompanying Form NIH-88-1 are routed through Radiation Safety, Bldg. 21, to the Procurement Section, Bldg. 13.

6. The purchase order will then be prepared by the Procurement Section, Material Management, and routed through the Radiation Safety Office for final approval. The Radiation Safety Officer will indicate approval and place the NRC license number on the purchase order and forward it to the supplier.

7. The Radiation Safety Office will be the receiving point on the NIH reservation for such material and will make the actual delivery to the ordering investigator. Any changes in the original shipping instructions should be furnished to this office by the investigator or the Institute ordering office serving him. Shipping information received from the supplier by the Procurement Section and the Receiving Control Reports Section, Bldg. 13, will be furnished immediately to the Radiation Safety Office which in turn will keep the ordering investigator properly informed.

8. In the case of ionizing radiation producing machines such as x-ray units, linear accelerators, etc., the notification is made on Form NIH–88–13, "Request for Authorization to Purchase and Use Radiation Producing Machinery or Equipment." The filing of Training and Experience Form NIH-88-2 may or may not be required by the Radiation Committee depending on the device(s), its complexity and the proposed uses. Consult with the Radiation Safety Officer concerning this Training and Experience requirement. The equipment is then requisitioned in the usual manner using Form PHS–402–1.

Shipping Radioactive Materials

1. When radioactive material is to be shipped from NIH, the shipper must notify the Radiation Safety Office instead of the Shipping and Receiving Section. The Radiation Safety staff will pick up these shipments on telephone request. The usual NIH shipping request Form NIH 1884 is to be prepared and will accompany the container. Under item 7 of this form the description of articles must include radionuclide, chemical form, and activity (in μCi or mCi).

2. The recipient of any material to be shipped from NIH must provide evidence of an NRC (or agreement state*) license by furnishing a copy of his license to the Radiation Safety Office before shipment can be made. Noncompliance with this requirement is a violation of the Atomic Energy Act and is subject to criminal prosecution as well as denial to NIH of further NRC-controlled radionuclides. Check first with the Radiation Safety staff by phone to see if the recipient's license is already on file. If not, then request a copy from the recipient in order to fulfill this requirement.

3. The investigator is reminded that the NIH specific license of broad scope *covers only the Bethesda reservation, Auburn Building and the Danac Buildings (4 and 5) in Rockville*. Materials transported by the investigator to other installations must be transferred to the respective licensees in that area as in paragraph 2 above and in a manner complying with applicable NRC and/or Department of Transportation regulations.

4. When an empty radionuclide container is to be returned to the supplier, the ordering investigator must notify the Radiation Safety Office, who will certify that it is free of contamination. The container may then be returned through normal channels. Promptness in returning the container is urged. Conditions of purchase usually require that such containers will be returned within a specified period of time.

*Agreement States: Those states that have entered into agreements with the NRC for the control of radioactive material.

†Off-site: All research locations other than the NIH reservation, the Auburn Building (Bethesda) and Danac Buildings 4 and 5 (Rockville) where NIH personnel are assigned.

Off-Site Use of Radionuclides by NIH Staff

As specified in NIH Manual Issuance 1344, NIH investigators working with radioactive materials and radiation producing devices will comply with the following:

1. All off-site† uses of radionuclides, domestic or foreign, under "generally licensed quantities" (10 CFR 31.100) or individual NRC or agreement state license should be subject to the same scientific review and approval by the Radiation Committee as prevails for in-house use.

2. Off-site domestic use under various forms of NRC or agreement state license of an NIH scientist may be permitted. This requires approval of the same type of application as is required for NIH use, plus approval of the application form as submitted to NRC or the agreement state, including specific data with respect to proposed methods of compliance with 10 CFR, Parts 19 and 20 or similar agreement state regulations. The NIH Radiation Safety Office will provide assistance with these applications and requires copies of all relevant correspondence, of the final licenses, of renewals, and of subsequent amendments to the licenses.

3. Off-site foreign use may be authorized following compliance with paragraph (1) and receipt by the Radiation Committee of an acceptable statement indicating the full knowledge and agreement of an appropriate authority in the host country.

4. All NIH scientists using radionuclides under any circumstances in off-site locations, domestic or foreign, must use NIH personnel monitoring devices when indicated or be under an equivalent monitoring program acceptable to and reporting to the NIH Radiation Safety Office.

5. The NIH Radiation Committee and Radiation Safety Office are authorized to intervene and apply the applicable NIH regulations to off-site uses of other sources of ionizing radiations employed by NIH personnel.

6. Users of radionuclides authorized and procured under the NIH Broad NRC License are reminded that this license is specific for the NIH *Bethesda reservation, Auburn Building, Danac Buildings 4 and 5, and other buildings specifically mentioned in amendments to the NIH Broad License*. This means that the transfer of radionuclides from these locations to off-site premises requires clearance through the NIH Radiation Safety Office. Transfers of radionuclides from off-site locations to NIH must be made in accordance with the requirements of "Procurement of Radiation Sources."

Glossary

ABSORBED DOSE: The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material. (See Rad)

ABSORPTION: The phenomenon by which radiation imparts some or all of its energy to any material through which it passes.

ACTIVITY: The number of nuclear disintegrations occurring in a given quantity of material per unit time. (See Curie)

ALPHA PARTICLE: A strongly ionizing particle emitted from the nucleus during radioactive decay having a mass and charge equal in magnitude to a helium nucleus, consisting of 2 protons and 2 neutrons with a double positive charge.

ALPHA RAY: A stream of fast-moving helium nuclei (alpha particles), a strongly ionizing and weakly penetrating radiation.

ANNIHILATION (Electron): An interaction between a positive and negative electron; their energy, including rest energy, being converted into electromagnetic radiation (annihilation radiation).

ATOM: Smallest particle of an element which is capable of entering into a chemical reaction.

AUTORADIOGRAPH: Record of radiation from radioactive material in an object, made by placing the object in close proximity to a photographic emulsion.

BACKGROUND RADIATION: Ionizing radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, etc.

BETA PARTICLE: Charged particle emitted from the nucleus of an atom, having a mass and charge equal in magnitude to that of the electron.

BETA RAY: A stream of high speed electrons or positrons of nuclear origin more penetrating but less ionizing than alpha rays.

BREMSSTRAHLUNG: Electromagnetic (x-ray) radiation associated with the deceleration of charged particles passing through matter. Usually associated with energetic beta emitters, e.g., phosphorus-32.

CALIBRATION: Determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors.

CONTAMINATION, RADIOACTIVE: Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful. The harm may be vitiating the validity of an experiment or a procedure, or in actually being a source of excessive exposure to personnel.

CARRIER FREE: An adjective applied to one or more radionuclides of an element in minute quantity, essentially undiluted with stable isotope carrier.

COUNT (Radiation Measurements): The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse.

CRITICAL ORGAN: That organ or tissue, the irradiation of which will result in the greatest hazard to the health of the individual or his descendants.

CURIE: The quantity of any radioactive material in which the number of disintegrations is 3.700×10^{10} per second. Abbrevated Ci.

Millicurie: One-thousandth of a curie (3.7×10^{7} disintegrations per second). Abbreviated mCi. Microcurie: One millionth of a curie (3.7×10^{4} disintegrations per second). Abbreviated μCi. Picocurie: One millionth of a microcurie (3.7×10^{-2} disintegrations per second or 2.22 disintegrations per minute). Abbreviated pCi.

DECAY, RADIOACTIVE: Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

DOSE: A general term denoting the quantity of radiation or energy absorbed in a specified mass. For special purposes it must be appropriately qualified, e.g., absorbed dose.

DOSE, ABSORBED: The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad, which is 100 ergs/gram.

DOSE EQUIVALENT: A quantity used in radiation protection expressing all radiation on a common scale for calculating the effective absorbed dose. The unit of dose equivalent is the rem, which is numerically equal to the absorbed dose in rads multiplied by certain modifying factors such as the quality factor, the distribution factor, etc.

EFFICIENCY (Counters): A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably so it is well to make sure which factors (window, transmission, sensitive volume, energy dependence, etc.) are included in a given case.

ELECTRON: Negatively charged elementary particle which is a constituent of every neutral atom. Its unit of negative electricity equals 4.8×10^{-10} coulombs. Its mass is 0.00549 atomic mass units.

ELECTRON CAPTURE: A mode of radioactive decay involving the capture of an orbital electron by its nucleus. Capture from the particular electron shell is designated as "K-electron capture," "L-electron capture," etc.

ELECTRON VOLT: A unit of energy equivalent to the amount of energy gained by an electron in passing through a potential difference of 1 volt. Abbreviated eV. Larger multiple units of the electron volt frequently used are: keV for thousand or kiloelectron volts, MeV for million electron volts and BeV for billion electron volts.

EXPOSURE: A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of air in the volume element. The special unit of exposure is the roentgen.

FILM BADGE: A packet of photographic film used for the approximate measurement of radiation exposure for personnel monitoring purposes. The badge may contain two or more films of differing sensitivity, and it may contain filters which shield parts of the film from certain types of radiation.

FILTER (Radiology), PRIMARY: A sheet of material, usually metal, placed in a beam of radiation to remove, as far as possible, the less penetrating components of the beam. **SECONDARY:** A sheet of material of lower atomic number, relative to that of the primary filter, placed in the filtered beam of radiation to remove characteristic radiation produced by the primary filter.

GAMMA RAY: Very penerating electromagnetic radiation of nuclear origin. Except for origin, identical to x-ray.

GEIGER-MUELLER (G-M) COUNTER: Highly sensitive gas-filled detector and associated circuitry used for radiation detection and measurement.

GENETIC EFFECT OF RADIATION: Inheritable changes, chiefly mutations, produced by the absorption of ionizing radiations. On the basis of present knowledge these effects are purely additive, and there is no recovery.

HALF-LIFE, BIOLOGICAL: The time required for the body to eliminate one-half of an administered dose of any substance by the regular processes of elimination. This time is approximately the same for both stable and radionuclides of a particular element.

HALF-LIFE, EFFECTIVE: Time required for a radioactive nuclide in a system to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

$$\text{Effective half-life} = \frac{\text{Biological half-life} \times \text{Radioactive half-life}}{\text{Biological half-life} + \text{Radioactive half-life}}$$

HALF-LIFE, RADIOACTIVE: Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

HALF VALUE LAYER (Half thickness): The thickness of any specified material necessary to reduce the intensity of an x-ray or gamma ray beam to one-half its original value.

HEALTH PHYSICS: A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

INVERSE SQUARE LAW: The intensity of radiation at any distance from a point source varies inversely as the square of that distance. For example: If the radiation exposure is 100 R/hr at 1 inch from a source, the exposure will be 0.01 R/hr at 100 inches.

ION: Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.

IONIZATION: The process by which a neutral atom or molecule acquires either a positive or a negative charge.

IONIZATION CHAMBER: An instrument designed to measure the quantity of ionizing radiation in terms of the charge of electricity associated with ions produced within a defined volume.

IONIZATION, SPECIFIC: The number of ion pairs per unit length of path of ionizing radiation in a medium; e.g., per centimeter of air or per micron of tissue.

IONIZING RADIATION: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

ISOTOPES: Nuclides having the same number of protons in their nuclei, and hence having the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element.

LABELED COMPOUND: A compound consisting, in part, of labeled molecules. By observations of radioactivity or isotopic composition this compound or its fragments may be followed through physical, chemical or biological processes.

MAXIMUM PERMISSIBLE DOSE (MPD): Maximum dose of radiation which may be received by persons working with ionizing radiation, which will produce no detectable damage over the normal life span.

MILLIROENTGEN (mR): A submultiple of the roentgen equal to one one-thousandth (1/1000th) of a roentgen. (See Roentgen)

MONITORING, RADIOLOGICAL: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

Area Monitoring: Routine monitoring of the level of radiation or of radioactive contamination of any particular area, building, room or equipment.

Personnel Monitoring: Monitoring any part of an individual, his breath, excretions, or any part of his clothing. (See Radiological Survey)

NEUTRON: Elementary particle with a mass approximately the same as that of a hydrogen atom and electrically neutral. It has a half-life in minutes and decays in a free state into a proton and an electron.

NUCLIDE: A species of atom characterized by its mass number, atomic number, and energy state of its nucleus, provided that the atom is capable of existing for a measurable time.

PROTECTIVE BARRIERS: Barriers of radiation absorbing material, such as lead, concrete, plaster, and plastic, that are used to reduce radiation exposure.

Protective Barriers, Primary: Barriers sufficient to attenuate the useful beam to the required degree.

Protective Barriers, Secondary: Barriers sufficient to attenuate stray or scattered radiation to the required degree.

RADIATION: 1. The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. 2. The energy propagated through a material medium as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term "radiation" or "radiant energy," when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified according to frequency as Hertzian, infrared, visible (light), ultraviolet, x-ray, and gamma ray. 3. By extension, corpuscular emissions, such as alpha and beta radiation, or rays of mixed or unknown type, as cosmic radiation.

RADIOLOGICAL SURVEY: Evaluation of the radiation hazards incident to the production, use or existence of radioactive materials or other sources of radiation under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

RADIONUCLIDE: A nuclide with an unstable ratio of neutrons to protons placing the nucleus in a state of stress. In an attempt to reorganize to a more stable state, it may undergo various types of rearrangement that involve the release of radiation.

RADIOTOXICITY: Term referring to the potential of an isotope to cause damage to living tissue by absorption of energy from the disintegration of the radioactive material introduced into the body.

RELATIVE BIOLOGICAL EFFECTIVENESS (RBE): For a particular living organism or part of an organism, the ratio of the absorbed dose of a reference radiation that produces a specified biological effect to the absorbed dose of the radiation of interest that produces the same biological effect.

REM: The special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, distribution factor, and any other necessary modifying factors.

ROENTGEN (R): The quantity of x or gamma radiation such that the associated corpuscular emission per 0.001293 grams of dry air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign. The roentgen is the special unit of exposure.

SCINTILLATION COUNTER: A counter in which light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photomultiplier tube.

SHIELDING MATERIAL: Any material which is used to absorb radiation and thus effectively reduce the intensity of radiation, and in some cases eliminate it. Lead, concrete, aluminum, water, and plastic are examples of commonly used shielding material.

SMEAR (Smear or Swipe Test): A procedure in which a swab, e.g., a circle of filter paper, is rubbed on a surface and its radioactivity measured to determine if the surface is contaminated with loose radioactive material.

SPECIFIC ACTIVITY: Total radioactivity of a given nuclide per gram of a compound, element or radioactive nuclide.

TRACER, ISOTOPIC: The isotope or nonnatural mixture of isotopes of an element which may be incorporated into a sample to make possible observation of the course of that element, alone or in combination, through a chemical, biological, or physical process. The observations may be made by measurement of radioactivity or of isotopic abundance.

THERMOLUMINESCENT DOSIMETER: A dosimeter made of certain crystalline material which is capable of both storing a fraction of absorbed ionizing radiation and releasing this energy in the form of visible photons when heated. The amount of light released can be used as a measure of radiation exposure to these crystals.

X-RAYS: Penetrating electromagnetic radiations having wave lengths shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In nuclear reactions it is customary to refer to photons originating in the nucleus as gamma rays, and those originating in the extranuclear part of the atom as x-rays. These rays are sometimes called roentgen rays after their discoverer, W. C. Roentgen.

GUIDELINES FOR MAXIMUM PERMISSIBLE DOSES FOR NIH PERSONNEL

Organ	Dose in mrem			
	Year	Quarter	Month	Week
Whole Body (Including Gonads, Lens of Eye, Red Bone Marrow)	5,000	1,250	400	100
Forearms, Hands, Feet and Ankles	75,000	18,750	6,250	1,500
Skin of Whole Body	30,000	7,500	2,500	650
Fertile Age Women*	3,000		250	60
Pregnant Women or Employees Under 18 Years of Age	500	125	40	10

For information on specific organs or tissues not listed, consult with Radiation Committee or Radiation Safety Officer.

* The National Council on Radiation Protection and Measurements, in Report No. 39, recommends a maximum permissible dose of 2 to 3 rem per year, at an even rate. Also see U.S. Nuclear Regulatory Commission Guide 8.13 in the Appendix.

CLASSIFICATION OF RADIONUCLIDES ACCORDING TO RELATIVE RADIOACTIVITY PER UNIT ACTIVITY
(Based on Published Data and NIH User Experience)

Class 1 (very high toxicity)
Sr-90 + Y-90, *Pb-210 + Bi-210(Ra D + E), Po-210, At-211, *Ra-226 + 55% *daughter products, Ac-227, *U-233, Pu-239, *Am-241, Cm-242, plus other transuranium isotopes.

Class 2 (high toxicity)
Ca-45, *Ca-47, *Fe-59, *Sr-85, Sr-89, Y-91, *Ru-106 + Rh-106, *I-125, *I-131, *Ba-140 + *La-140, Ce-144 + *Pr-144, Sm-151, *Eu-154, *Tm-170, *Hg-203, *Th-234 + *Pa-234, *natural uranium.

Class 3 (moderate toxicity)
*Na-22, *Na-24, P-32, P-33, S-35, Cl-36, *K-42, *Sc-46, *Sc-47, *Sc-48, *V-48, *Mn-52, *Mn-54, *Mn-56, Fe-55, *Co-57, *Co-58, *Co-60, Ni-59, *Cu-64, *Cu-67, *Zn-65, *Ga-67, *Ga-72, *As-74, *As-76, *Br-82, *Kr-85, *Rb-84, *Rb-86, *Zr-95 + *Nb-95, *Nb-95, *Mo-99, Tc-98, *Rh-105, Pd-103 + Rh-103, *Ag-105, *Ag-111, Cd-109 + *Ag-109, *Sn-113, *Te-127, *Te-129, *I-132, *Xe-133, *Cs-137 + *Ba-137, *La-140, Pr-143, Pm-147, *Ho-166, *Lu-177, *Ta-182, *W-181, *Re-183, Ir-190, *Ir-192, Pt-191, *Pt-193, *Au-196, *Au-198, *Au-199, Tl-200, Tl-202, Tl-204, *Pb-203, *Hg-197.

Class 4 (slight toxicity)
H-3, Be-7, C-14, *F-18, *Cr-51, Ge-71, *Sr-87m, *Tc-99m, *Tl-201.

*Gamma emitter and/or associated photon emitter.

GUIDELINES FOR MAXIMUM ACTIVITIES IN NIH LABORATORIES

Radiotoxicity of Radionuclides	Minimum Significant Quantity Utilized	Typical NIH Laboratory	Radionuclide Laboratory Building 21 (1)
Very high	0.1 μCi	10 μCi or less	10 μCi–10 mCi
High	1.0 μCi	100 μCi or less	100 μCi–100 mCi
Moderate	10 μCi	1 mCi or less	1 mCi–1 Ci
Slight	100 μCi	10 mci or less	10 mCi–10 Ci

Modifying factors should be applied to the quantities indicated in the last 2 columns of the above table, according to the complexity of the procedures to be followed. The following factors are suggested but due regard should be paid to the circumstances affecting individual cases.

Procedure	*Modifying factor*
Storage (stock solutions)	× 100
Very simple wet operations	× 10
Normal chemical operations	× 1
Complex wet operations with risk of spills	× 0.1
Simple dry operations	× 0.1
Dry and dusty operations	× 0.01

(1) With proper documentation of experimental protocol and with approval of the Radiation Committee, investigators may be permitted to use these quantities in NIH laboratories outside Building 21. With similar documentation, activities exceeding these maximum quantities may be approved for use in Building 21 only.

SELECTED PROPERTIES OF MOST FREQUENTLY ORDERED RADIONUCLIDES

Nuclide	Maximum Beta Energy (MeV)	Gamma Energy (MeV)	Iγ mR/hr/mCi at 1 m	Critical organ	MPB (μCi)	Half-Life	
						Radioactive	Biological (days)
^{3}H	0.0186			Body Tissue	2000	12.26y	12
^{14}C	0.156			Body Fat	180	5730y	12
^{24}Na	1.389	1.369 (100%) 2.754 (100%)	1.84	Total Body	7	14.96h	11
^{32}P	1.710			Bone	3	14.28d	1155
^{32}P	0.248			Bone	32	24.4d	1155
^{35}S	0.167			Testis Total Body	0.18 400	87.9d	623
^{51}Cr		0.32(9%)	0.016	Total Body	1100	27.8d	616
^{125}I		28 keV average (143%)	0.07	Thyroid	0.57	60.2d	138
^{131}I	0.606	0.637 (6.8%) 0.364 (82%)	0.22	Thyroid	0.078	8.05d	138

Column (4), Iγ Milliroentgens per hour at 1 meter from 1 millicurie.

Column (5), Critical organ. The organ that receives the limiting dose equivalent from a substained burden (see discussion of Column 6). These organs are chosen based on the way in which the radioactive material is distributed within the body after intake.

Column (6), Maximum Permissible Burden (MPB). The amount of a radionuclide in an organ which, when sustained in that organ continuously, would produce the maximum permissible dose equivalent. The corresponding maximum permissible dose equivalents for the organs above are: body fat and thyroid, 15 rem/yr; and all others 5 rem/yr.

Column (7), Radioactive Half-Life. Present best value, obtained from "Table of Isotopes—6th Edition" by C. M. Lederer, J. M. Hollander, and I. Perlman, John Wiley & Sons, New York, 1967. The abbreviations used here are: s, second; m, minute; h, hour; d, day; and y, year.

Column (8), Biological Half-Life. The time required for one-half of the stable element to be removed from the critical organ by biological processes, as listed by the ICRP. The actual half-life of elimination depends also on the half-life of the isotope. The "effective half-life" in the critical organ (T_{eff}) is given by $T_{eff} = \frac{T_r T_b}{T_r + T_b}$ where T_r is the radioactive half-life and T_b is the biological half-life.

Rules of Thumb

Beta Particles

a. Beta particles of at least 70 keV energy are required to penetrate the nominal protective layer of the skin (7 mg/cm² or 0.07 mm).

b. The average energy of a beta-ray spectrum is approximately one-third the maximum energy.

c. The range of beta particles in air is ~ 12 ft/MeV. (Maximum range of ^{32}P beta is 1.71 MeV × 12 ft/Mev ≅ 20 ft).

d. The dose rate in rads per hour in a solution by a beta emitter is 1.12 EC/ρ, where E is the average beta energy per disintegration in MeV, C is the concentration in microcuries per cubic centimeter, and ρ is the density of the medium in grams per cubic centimeter. The dose rate at the surface of the solution is one-half the value given by this relation. (For ^{32}P average energy of approximately 0.7 MeV, the dose rate from 1 μCi/cm³ (in water) is 1.48 rads/hr).

e. The surface dose rate through the nominal protective layer of skin (7 mg/cm²) from a uniform thin deposition of 1 μCi/cm² is about 9 rads/hour for energies above about 0.6 MeV. Note that in a thin layer, the beta dose rate exceeds the gamma dose rate, for equal energies released, by about a factor of 100.

f. For a point source of beta radiation (neglecting self and air absorption) of strength mCi millicuries, the dose rate at 1 cm is approximately equal to 200 × mCi rads/hour and varies only slowly with beta energy. Dose rate for 1 mCi ^{32}P at 1 cm is approximately 200 rads/hour.

Gamma Rays

a. For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate (mR/hr) within ± 20% at 1 foot is 6 × mCi × E × n, where mCi is the number of millicuries; E, the energy in MeV; and n, the number of gammas per disintegration.

b. The dose rate to tissue in rads per hour in an infinite medium uniformly contaminated by a gamma emitter is 2.12 EC/ρ, where C is the number of microcuries per cubic centimeter, E is the average gamma energy per disintegration in MeV, and ρ is the density of the medium. At the surface of a large body, the dose rate is about half of this.

X-Ray

a. The exposure rate at 2 feet from diagnostic x-ray equipment operated at 100 kVp and 100 milliamperes is approximately 2.3 roentgens/second.

b. Exposure rate at the fluoroscopy table with tube potential at 80 kVp and tube current of 1 milliampere should not exceed 2.1 roentgens/minute.

c. Scattered radiation can be as penetrating as the primary beam.

X-Ray Diffraction

a. The x-ray beam intensities from the primary beam can be as much as 400,000 R/min.

b. Scattered radiation 10 cm from the points of scatter about the x-ray tube head has been measured in the order of 150 R/hr.

c. The threshold dose sufficient to produce skin erythema is 300 to 400 roentgens.

d. The minimum cataractogenic single dose is 200 rads, while a dose of 750 rads exhibits a high incidence of cataract formation.

Miscellaneous

a. The activity of any radionuclide is reduced to less than 1% after 7 half-lives (i.e., 2^{-7} = 0.8%).

b. For material with a half-life greater than six days, the change in activity in 24 hours will be less than 10%.

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D.C. 20555

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

WHAT IS THE NUCLEAR REGULATORY COMMISSION?

The Nuclear Regulatory Commission is an independent Federal regulatory agency responsible for licensing and inspecting nuclear power plants and other commercial uses of radioactive materials.

WHAT DOES THE NRC DO?

The NRC's primary responsibility is to ensure that workers and the public are protected from unnecessary or excessive exposure to radiation and that nuclear facilities including power plants are constructed to high quality standards and operated in a safe manner. The NRC does this by establishing requirements in Title 10 of the Code of Federal Regulations (10 CFR) and in licenses issued to nuclear users.

WHAT RESPONSIBILITY DOES MY EMPLOYER HAVE?

Any company that conducts activities licensed by the NRC must comply with the NRC's requirements. If a company violates NRC requirements, it can be fined or have its license modified, suspended or revoked.

Your employer must tell you which NRC radiation requirements apply to your work and must post NRC Notices of Violation involving radiological working conditions.

WHAT IS MY RESPONSIBILITY?

For your own protection and the protection of your co-workers, you should know how NRC requirements relate to your work and should obey them. If you observe violations of the requirements, you should report them.

HOW DO I REPORT VIOLATIONS?

If you believe that violations of NRC rules or of the terms of the license have occurred, you should report them immediately to your supervisor. If you believe that adequate corrective action is not being taken, you may report this to an NRC inspector or the nearest NRC Regional Office.

WHAT IF I WORK IN A RADIATION AREA?

If you work with radioactive materials or in a radiation (controlled) area, the amount of radiation exposure that you may legally receive is limited by NRC Regulations. The limits on your exposure are contained in sections 20.101, 20.103, and 20.104 of Title 10 of the Code of Federal Regulations (10 CFR 20). While those are the maximum allowable limits, your employer should also keep your radiation exposure as far below those limits as is "reasonably achievable."

MAY I GET A RECORD OF MY RADIATION EXPOSURE?

Yes. Your employer is required to tell you, in writing, if you receive any radiation exposure above the limits set in the NRC regulations or your employer's license. In addition, if your job involves radiation, you may request from your employer a record of your annual radiation exposures and a written report of your total exposure when you leave your job.

HOW ARE VIOLATIONS OF NRC REQUIREMENTS IDENTIFIED?

NRC conducts regular inspections at licensed facilities to assure compliance with NRC requirements. In addition, your employer and site contractors conduct their own inspections to assure compliance. All inspectors are protected by Federal law. Interference with them may result in criminal prosecution for a Federal offense.

MAY I TALK WITH AN NRC INSPECTOR?

Yes. Your employer may not prevent you from talking with an NRC inspector and you may talk privately with an inspector and request that your identity remain confidential.

MAY I REQUEST AN INSPECTION?

If you believe that your employer has not corrected violations involving radiological working conditions, you may request an inspection. Your request should be addressed to the nearest NRC Regional Office and must describe the alleged violation in detail. It must be signed by you or your representative.

HOW DO I CONTACT THE NRC?

Notify an NRC inspector on-site or call the nearest NRC Regional office collect. NRC inspectors want to talk to you if you are worried about radiation safety or other aspects of licensed activities, such as the quality of construction or operations at your plant.

CAN I BE FIRED FOR TALKING TO THE NRC?

No. Federal law prohibits an employer from firing or otherwise discriminating against a worker for bringing safety concerns to the attention of the NRC. You may not be fired or discriminated against because you:

- ask the NRC to enforce its rules against your employer;
- testify in an NRC proceeding;
- provide information or are about to provide information to the NRC about violations of requirements;
- are about to ask for or testify, help, or take part in an NRC proceeding.

WHAT FORMS OF DISCRIMINATION ARE PROHIBITED?

No employer may fire you or discriminate against you with respect to pay, benefits, or working conditions because you help the NRC.

HOW AM I PROTECTED FROM DISCRIMINATION?

If you believe that you have been discriminated against for bringing safety concerns to the NRC, you may file a complaint with the U.S. Department of Labor. Your complaint must describe the firing or discrimination and must be filed within 30 days of the occurrence.

Send complaints to:

Office of the Administrator
Wage and Hour Division
Employment Standards Administration
U.S. Department of Labor
Room 53502
200 Constitution Avenue, N.W.
Washington, D.C. 20210

or any local office of the Department of Labor, Wage and Hour Division. Check your telephone directory under U.S. Government listings.

WHAT CAN THE LABOR DEPARTMENT DO?

The Department of Labor will notify the employer that a complaint has been filed and will investigate the case.

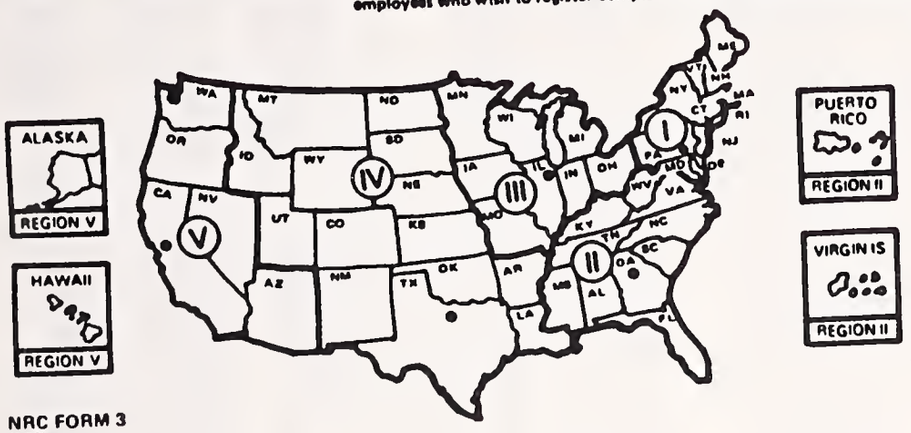
If the Department of Labor finds that your employer has unlawfully discriminated against you, it may order you to be reinstated, receive back pay, or be compensated for any injury suffered as a result of the discrimination.

WHAT WILL THE NRC DO?

The NRC may assist the Department of Labor in its investigation. NRC may conduct its own investigation where necessary to determine whether unlawful discrimination has prevented the free flow of information to the Commission. Also, if the NRC or Department of Labor finds that unlawful discrimination has occurred, the NRC may issue a Notice of Violation to your employer, impose a fine, or suspend, modify, or revoke your employer's NRC license.

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

A representative of the Nuclear Regulatory Commission can be contacted at the following addresses and telephone numbers. The Regional Office will accept collect telephone calls from employees who wish to register complaints or concerns about radiological working conditions or other matters regarding compliance with Commission rules and regulations.



Regional Offices

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission Region I 475 Allendale Road King of Prussia, PA 19406	215 337-5000
II	U.S. Nuclear Regulatory Commission Region II 101 Marietta St., N.W. Atlanta, GA 30323	404 331-4503
III	U.S. Nuclear Regulatory Commission Region III 799 Roosevelt Road Glen Ellyn, IL 60137	312 790-5500
IV	U.S. Nuclear Regulatory Commission Region IV 611 Ryan Plaza Drive, Suite 1000 Arlington, TX 76011	817 860-8100
V	U.S. Nuclear Regulatory Commission Region V 1450 Maria Lane, Suite 210 Walnut Creek, CA 94596	415 943 3700

NRC FORM 3
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U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.13
(Task OP 031-4)

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12, "Instructions to Workers," of 10 CFR Part 19, "Notices, Instructions, and Reports to Workers; Inspections," requires that all individuals working in or frequenting any portion of a restricted area[1] be instructed in the health protection problems associated with exposure to radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the regulations that they are expected to observe. The present 10 CFR Part 20, "Standards for Protection Against Radiation," has no special limit for exposure of the embryo/fetus.[2] This guide describes the instructions an employer should provide to workers and supervisors concerning biological risks to the embryo/fetus exposed to radiation, a dose limit for the embryo/fetus that is under consideration, and suggestions for reducing radiation exposure.

This regulatory guide takes into consideration a proposed revision to 10 CFR Part 20, which incorporates the radiation protection guidance for the embryo/fetus approved by the President in January 1987 (Ref. 1). This revision to Part 20 was issued in January 1986 for comment as a proposed rule. Comments on the guide as it pertains to the proposed Part 20 are encouraged. If the new Part 20 is codified, this regulatory guide will be revised to conform to the new regulation and will incorporate appropriate public comments.

Any information collection activities mentioned in this regulatory guide are contained as requirements in 10 CFR Parts 19 or 20, which provide the regulatory basis for this guide. The information collection requirements in 10 CFR Parts 19 and 20 have been cleared under OMB Clearance Nos. 3150-0044 and 3150-0014, respectively.

B. DISCUSSION

It has been known since 1906 that cells that are dividing very rapidly and are undifferentiated in their structure and function are generally more sensitive to radiation. In the embryo stage, cells meet both these criteria and thus would be expected to be highly sensitive to radiation. Furthermore, there is direct evidence that the embryo/fetus is radiosensitive. There is also evidence that it is especially sensitive to certain radiation effects during certain periods after conception, particularly during the first 2 to 3 months after conception when a woman may not be aware that she is pregnant.

Section 20.104 of 10 CFR Part 20 places different radiation dose limits on workers who are minors than on adult workers. Workers under the age of 18 are limited to one-tenth of the adult radiation dose limits. However, the present NRC regulations do not establish dose limits specifically for the embryo/fetus.

The NRC's present limit on the radiation dose that can be received on the job is 1,250 millirems per quarter (3 months).[3] Working minors (those under 18) are limited to a dose equal to one-tenth that of adults, 125 millirems per quarter. (See § 20.101 of 10 CFR Part 20.)

Because of the sensitivity of the unborn child, the National Council on Radiation Protection and Measurements (NCRP) has recommended that the dose equivalent

[1] Restricted area means any area that has controlled access to protect individuals from being exposed to radiation and radioactive materials.

[2] In conformity with the proposed revision to 10 CFR Part 20, the term "embryo/fetus" is used throughout this document to represent all stages of pregnancy.

[3] The limit is 3,000 millirems per quarter if the worker's occupational dose history is known and the average dose does not exceed 5,000 millirems per year.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Written comments may be submitted to the Rules and Procedures Branch, DRR, ADM, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust and Financial Review
10. General

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Issued guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161.

to the unborn child from occupational exposure of the expectant mother be limited to 500 millirems for the entire pregnancy (Ref. 2). The 1987 Presidential guidance (Ref. 1) specifies an effective dose equivalent limit of 500 millirems to the unborn child if the pregnancy has been declared by the mother; the guidance also recommends that substantial variations in the rate of exposure be avoided. The NRC (in § 20.208 of its proposed revision to Part 20) has proposed adoption of the above limits on dose and rate of exposure.

In 1971, the NCRP commented on the occupational exposure of fertile women (Ref. 2) and suggested that fertile women should be employed only where the annual dose would be unlikely to exceed 2 or 3 rems and would be accumulated at a more or less steady rate. In 1977, the ICRP recommended that, when pregnancy has been diagnosed, the woman work only where it is unlikely that the annual dose would exceed 0.30 of the dose-equivalent limit of 5 rems (Ref. 3). In other words, the ICRP has recommended that pregnant women not work where the annual dose might exceed 1.5 rem.

C. REGULATORY POSITION

Instructions on radiation risks should be provided to workers, including supervisors, in accordance with § 19.12 of 10 CFR Part 19 before they are allowed to work in a restricted area. In providing instructions on radiation risks, employers should include specific instructions about the risks of radiation exposure to the embryo/fetus.

The instructions should be presented both orally and in printed form, and the instructions should include, as a minimum, the information provided in Appendix A (Instructor's Guide) to this guide. Individuals should be given the opportunity to ask questions and in turn should be questioned to determine whether they understand the instructions. An acceptable method of ensuring that the information is understood is to give a simple written test covering the material included in Appendix B (Pregnant Worker's Guide). This approach should highlight for instructors those parts of the instructions that cause difficulties and thereby lead to appropriate modifications in the instructional curriculum.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the NRC will use the material described in this guide to evaluate the instructional program presented to individuals, including supervisors, working in or frequenting any portion of a restricted area.

APPENDIX A

INSTRUCTOR'S GUIDE

EFFECTS ON THE EMBRYO/FETUS OF EXPOSURE TO RADIATION AND OTHER ENVIRONMENTAL HAZARDS

In order to decide whether to continue working while exposed to ionizing radiation during her pregnancy, a woman should understand the potential effects on an embryo/fetus, including those that may be produced by various environmental risks such as smoking and drinking. This will allow her to compare these risks with those produced by exposure to ionizing radiation.

Table 1 provides information on the potential effects resulting from exposure of an embryo/fetus to radiation and nonradiation risks. The second column gives the rate at which the effect is produced by natural causes in terms of the number per thousand cases. The fourth column gives the number of additional effects per thousand cases believed to be produced by exposure to the specified amount of the risk factor.

The following section discusses the studies from which the information in Table 1 was derived. The results of exposure of the embryo/fetus to the risk factors and the dependence on the amount of the exposure are explained.

1. RADIATION RISKS

1.1 Childhood Cancer

Numerous studies of radiation-induced childhood cancer have been performed, but a number of them are controversial. The National Academy of Science (NAS) BEIR report reevaluated the data from these studies and even reanalyzed the results. Some of the strongest support for a causal relationship is provided by twin data from the Oxford survey (Ref. 4). For maternal radiation doses of 1,000 millirems, the excess number of deaths (above those occurring from natural causes) was found to be 0.6 death per thousand children (Ref. 4).

1.2 Mental Retardation and Abnormal Smallness of the Head (Microcephaly)

Studies of Japanese children who were exposed while in the womb to the atomic bomb radiation at Hiroshima and Nagasaki have shown evidence of both small head size and mental retardation. Most of the children were exposed to radiation doses in the range of 1 to 50 rads. The importance of the most recent study lies in the fact that investigators were able to show that the gestational age (age of the embryo/fetus after conception) at the time the children were exposed was a critical factor (Ref. 7). The approximate risk of small head size as a function of gestational age is shown in Table 1. For a radiation dose of 1,000 millirems at 4 to 7 weeks after conception, the excess cases of small head size was 5 per thousand; at 8 to 11 weeks, it was 9 per thousand (Ref. 7).

In another study, the highest risk of mental retardation occurred during the 8 to 15 week period after conception (Ref. 8). A recent EPA study (Ref. 16) has calculated that excess cases of mental retardation per live birth lie between 0.5 and 4 per thousand per rad.

1.3 Genetic Effects

Radiation-induced genetic effects have not been observed to date in humans. The largest source of material for genetic studies involves the survivors of Hiroshima and Nagasaki, but the 77,000 births that occurred among the survivors showed no evidence of genetic effects. For doses received by the pregnant worker in the course of employment considered in this guide, the dose received by the embryo/fetus apparently would have a negligible effect on descendants (Refs. 17 and 18).

2. NONRADIATION RISKS

2.1 Occupation

A recent study (Ref. 9) involving the birth records of 130,000 children in the State of Washington indicates that the risk of death to the unborn child is related to the occupation of the mother. Workers in the metal industry, the chemical industry, medical technology, the wood industry, the textile industry, and farms exhibited stillbirths or spontaneous abortions at a rate of 90 per thousand above that of workers in the control group, which consisted of workers in several other industries.

2.2 Alcohol

It has been recognized since ancient times that alcohol consumption had an effect on the unborn child. Carthaginian law forbade the consumption of wine on the wedding night so that a defective child might not be conceived. Recent studies have indicated that small amounts of alcohol consumption have only the minor effect of reducing the birth weight slightly, but when consumption increases to 2 to 4 drinks per day, a pattern of abnormalities called the fetal alcohol syndrome (FAS) begins to appear (Ref. 11). This syndrome consists of reduced growth in the unborn child, faulty brain function, and abnormal facial features. There is a syndrome that has the same symptoms as full-blown FAS that occurs in children born to mothers who have not consumed alcohol. This naturally occurring syndrome occurs in about 1 to 2 cases per thousand (Ref. 10).

TABLE 1

EFFECTS OF RISK FACTORS ON PREGNANCY OUTCOME

Effect	Number Occurring from Natural Causes	Risk Factor	Excess Occurrences from Risk Factor
		RADIATION RISKS	
		Childhood Cancer	
Cancer death in children	1.4 per thousand (Ref. 5)	Radiation dose of 1000 millirems received before birth	0.6 per thousand (Ref. 4)
		Abnormalities	
		Radiation dose of 1000 millirads received during specific periods after conception:	
Small head size	40 per thousand (Ref. 6)	4-7 weeks after conception	5 per thousand (Ref. 7)
Small head size	40 per thousand (Ref. 6)	8-11 weeks after conception	9 per thousand (Ref. 7)
Mental retardation	4 per thousand (Ref. 8)	Radiation dose of 1000 millirads received 8 to 15 weeks after conception	4 per thousand (Ref. 8)
		NONRADIATION RISKS	
		Occupation	
Stillbirth or spontaneous abortion	200 per thousand (Ref. 9)	Work in high-risk occupations (see text)	90 per thousand (Ref. 9)
		Alcohol Consumption (see text)	
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	2-4 drinks per day	100 per thousand (Ref. 11)
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	More than 4 drinks per day	200 per thousand (Ref. 11)
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	Chronic alcoholic (more than 10 drinks per day)	350 per thousand (Ref. 12)
Perinatal infant death (around the time of birth)	23 per thousand (Refs. 13, 14)	Chronic alcoholic (more than 10 drinks per day)	170 per thousand (Ref. 15)
		Smoking	
Perinatal infant death	23 per thousand (Refs. 13, 14)	Less than 1 pack per day	5 per thousand (Ref. 13)
Perinatal infant death	23 per thousand (Refs. 13, 14)	One pack or more per day	10 per thousand (Ref. 13)

For mothers who consume 2 to 4 drinks per day, the excess occurrences number about 100 per thousand; and for those who consume more than 4 drinks per day, excess occurrences number 200 per thousand. The most sensitive period for this effect of alcohol appears to be the first few weeks after conception, before the mother-to-be realizes she is pregnant (Refs. 10 and 11). Also, 17% or 170 per thousand of the embryo/fetuses of chronic alcoholics develop FAS and die before birth (Ref. 15). FAS was first identified in 1973 in the United States where less than full-blown effects of the syndrome are now referred to as fetal alcohol effects (FAE) (Ref. 12).

2.3 Smoking

Smoking during pregnancy causes reduced birth weights in babies amounting to 5 to 9 ounces on the average. In addition, there is an increased risk of 5 infant deaths per thousand for mothers who smoke less than one pack per day and 10 infant deaths per thousand for mothers who smoke one or more packs per day (Ref. 13).

2.4 Miscellaneous

Numerous other risks affect the embryo/fetus, only a few of which are touched upon here. Most people are familiar with the drug thalidomide (a sedative given to some pregnant women), which causes children to be born with missing limbs, and the more recent use of the drug diethylstilbestrol (DES), a synthetic estrogen given to some women to treat menstrual disorders, which produced vaginal cancers in the daughters born to women who took the drug. Living at high altitudes also gives rise to an increase in the number of low-birth-weight children born, while an increase in Down's Syndrome (mongolism) occurs in children born to mothers who are over 35 years of age. The rapid growth in the use of ultrasound in recent years has sparked an ongoing investigation into the risks of using ultrasound for diagnostic procedures (Ref. 19).

APPENDIX B

PREGNANT WORKER'S GUIDE

POSSIBLE HEALTH RISKS TO CHILDREN OF WOMEN WHO ARE EXPOSED TO RADIATION DURING PREGNANCY

During pregnancy, you should be aware of things in your surroundings or in your style of life that could affect your unborn child. For those of you who work in or visit areas designated as Restricted Areas (where access is controlled to protect individuals from being exposed to radiation and radioactive materials), it is desirable that you understand the biological risks of radiation to your unborn child.

Everyone is exposed daily to various kinds of radiation: heat, light, ultraviolet, microwave, ionizing, and so on. For the purposes of this guide, only ionizing radiation (such as x-rays, gamma rays, neutrons, and other high-speed atomic particles) is considered. Actually, everything is radioactive and all human activities involve exposure to radiation. People are exposed to different amounts of natural "background" ionizing radiation depending on where they live. Radon gas in homes is a problem of growing concern. Background radiation comes from three sources:

	Average Annual Dose
Terrestrial - radiation from soil and rocks	50 millirem
Cosmic - radiation from outer space	50 millirem
Radioactivity normally found within the human body	25 millirem
	125 millirem*
Dosage range (geographic and other factors)	75 to 5,000 millirem

The first two of these sources expose the body from the outside, and the last one exposes it from the inside. The average person is thus exposed to a total dose of about 125 millirems per year from natural background radiation.

In addition to exposure from normal background radiation, medical procedures may contribute to the dose people receive. The following table lists the average doses received by the bone marrow (the blood-forming cells) from different medical applications.

X-Ray Procedure	Average Dose*
Normal chest examination	10 millirem
Normal dental examination	10 millirem
Rib cage examination	140 millirem
Gall bladder examination	170 millirem
Barium enema examination	500 millirem
Pelvic examination	600 millirem

*Variations by a factor of 2 (above and below) are not unusual.

*Radiation doses in this document are described in two different units. The rad is a measure of the amount of energy absorbed in a certain amount of material (100 ergs per gram). Equal amounts of energy absorbed from different types of radiation may lead to different biological effects. The rem is a unit that reflects the biological damage done to the body. The millirad and millirem refer to 1/1000 of a rad and a rem, respectively.

NRC POSITION

NRC regulations and guidance are based on the conservative assumption that any amount of radiation, no matter how small, can have a harmful effect on an adult, child, or unborn child. This assumption is said to be conservative because there are no data showing ill effects from small doses; the National Academy of Sciences recently expressed "uncertainty as to whether a dose of, say, 1 rad would have any effect at all." Although it is known that the unborn child is more sensitive to radiation than adults, particularly during certain stages of development, the NRC has not established a special dose limit for protection of the unborn child. Such a limit could result in job discrimination for women of child-bearing age and perhaps in the invasion of privacy (if pregnancy tests were required) if a separate regulatory dose limit were specified for the unborn child. Therefore, the NRC has taken the position that special protection of the unborn child should be *voluntary* and should be based on decisions made by workers and employers who are well informed about the risks involved.

For the NRC position to be effective, it is important that both the employee and the employer understand the risk to the unborn child from radiation received as a result of the occupational exposure of the mother. This document tries to explain the risk as clearly as possible and to compare it with other risks to the unborn child during pregnancy. It is hoped this will help pregnant employees balance the risk to the unborn child against the benefits of employment to decide if the risk is worth taking. This document also discusses methods of keeping the dose, and therefore the risk, to the unborn child as low as is reasonably achievable.

RADIATION DOSE LIMITS

The NRC's present limit on the radiation dose that can be received on the job is 1,250 millirems per quarter (3 months).* Working minors (those under 18) are limited to a dose equal to one-tenth that of adults, 125 millirems per quarter. (See § 20.101 of 10 CFR Part 20.)

Because of the sensitivity of the unborn child, the National Council on Radiation Protection and Measurements (NCRP) has recommended that the dose equivalent to the unborn child from occupational exposure of the expectant mother be limited to 500 millirems for the entire pregnancy (Ref. 2). The 1987 Presidential guidance (Ref. 1) specifies an effective dose equivalent limit of 500 millirems to the unborn child if the pregnancy has been declared by the mother; the guidance also recommends that substantial variations in the rate of exposure be avoided. The NRC (in § 20.208 of its proposed revision to Part 20) has proposed adoption of the above limits on dose and rate of exposure.

ADVICE FOR EMPLOYEE AND EMPLOYER

Although the risks to the unborn child are small under normal working conditions, it is still advisable to limit the radiation dose from occupational exposure to no more than 500 millirems for the total pregnancy. Employee and employer should work together to decide the best method for accomplishing this goal. Some methods that might be used include reducing the time spent in radiation areas, wearing some shielding over the abdominal area, and keeping an extra distance from radiation sources when possible. The employer or health physicist will be able to estimate the probable dose to the unborn child during the normal nine-month pregnancy period and to inform the employee of the amount. If the predicted dose exceeds 500 millirems, the employee and employer should work out schedules or procedures to limit the dose to the 500-millirem recommended limit.

It is important that the employee inform the employer of her condition as soon as she realizes she is pregnant if the dose to the unborn child is to be minimized.

INTERNAL HAZARDS

This document has been directed primarily toward a discussion of radiation doses received from sources outside the body. Workers should also be aware that there is a risk of radioactive material entering the body in workplaces where unsealed radioactive material is used. Nuclear medicine clinics, laboratories, and certain manufacturers use radioactive material in bulk form, often as a liquid or a gas. A list of the commonly used materials and safety precautions for each is beyond the scope of this document, but certain general precautions might include the following:

1. Do not smoke, eat, drink, or apply cosmetics around radioactive material.
2. Do not pipette solutions by mouth.
3. Use disposable gloves while handling radioactive material when feasible.
4. Wash hands after working around radioactive material.
5. Wear lab coats or other protective clothing whenever there is a possibility of spills.

Remember that the employer is required to have demonstrated that it will have safe procedures and practices before the NRC issues it a license to use radioactive material. Workers are urged to follow established procedures and consult the employer's radiation safety officer or health physicist whenever problems or questions arise.

*The limit is 3,000 millirems per quarter if the worker's occupational dose history is known and the average dose does not exceed 5,000 millirems per year.

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